

## **SECTION 1: INTRODUCTION**

### **1.1 Purpose**

The purpose of the Stormwater Management Manual is to provide engineers, developers, property owners and managers, and interested citizens with information on stormwater management requirements, technical guidance on the methodology that can be used to meet the requirements, and guidelines for designing, implementing, and maintaining Best Management Practices (BMPs) that may be used in the City of Greensboro to improve the quality of surface waters, and minimize the stormwater runoff volume and discharge rates from developed areas. This manual will explain the need for stormwater management in Greensboro and describe the minimum design requirements and accepted methodology for meeting City ordinance requirements. The manual also includes a comprehensive review of the most effective BMPs currently used for stormwater management: which BMPs work best for different development scenarios, which BMPs may be implemented to meet different regulatory requirements, and those BMPs that can be used to receive credit on the stormwater utility fee. The manual provides design, installation, and maintenance guidelines for various BMPs to increase the options for stormwater BMPs and to improve BMP's water quality functionality, ease of maintenance, and longevity.

This manual is not intended to stifle creativity of the designer; rather the City encourages and is open to reviewing new procedures, techniques, and stormwater best management practices where they can be shown to be appropriate by the design professional. While the City intends to develop stormwater quantity and quality management master plans for all watersheds within the city limits to serve as guidance for drainage system and best management practice design, the responsibility for adequate and appropriate stormwater management control measures for a given site remains with the qualified design professional.

Because urban stormwater quantity and quality management is a relatively new practice, design guidelines will likely be changing in the future as the needs for each watershed and sub-watershed are determined in the master planning process, new technologies are developed based information obtained from long-term monitoring data, and changes occur in regulatory requirements. The City will strive to keep this manual updated to allow for increased flexibility and efficiency in stormwater management.

### **1.2 Need for Stormwater Management**

#### *1.2.1 Effects of Urbanization on Watershed Hydrology and Pollutant Loading*

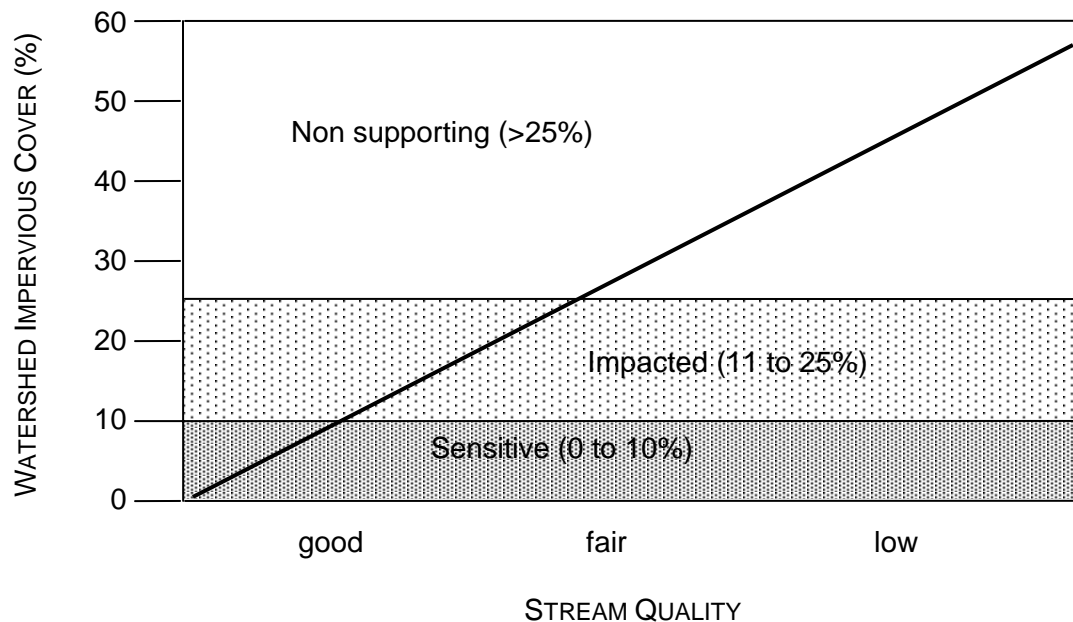
Changes in the land use in Greensboro resulting from urbanization have affected the regional hydrology and pollutant loading in stormwater runoff. This has resulted in increased stormwater quantity and quality problems including:

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- ⇒ degradation of overall water quality
- ⇒ floodplain expansion
- ⇒ increased flooding frequency
- ⇒ stream channel enlargement and erosion
- ⇒ changes in stream flow patterns (high storm flows, low dry weather flow)
- ⇒ loss of stream habitat
- ⇒ decline in stream biological function
- ⇒ property damage and safety concerns
- ⇒ unsightly stream channel conditions

Research has generally shown that impacts to surface waters are directly related to watershed imperviousness and that impacts can begin to be significant when the watershed reaches the threshold value of 10% imperviousness (Figure 1.1).

**Figure 1.1: Relationship Between Impervious Cover and Stream Quality**



SOURCE: SCHUELER

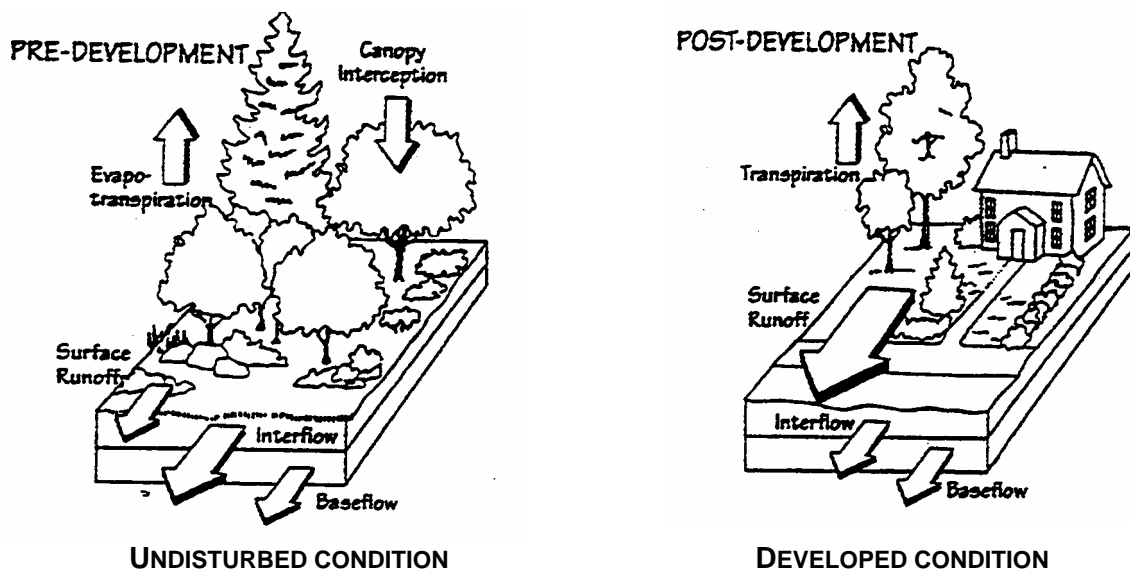
### Watershed Hydrology

Undisturbed areas have vegetation and organic topsoil that intercept precipitation and a natural topography that consists of small depressions that store precipitation and allow a significant fraction of precipitation to infiltrate into the ground. As these areas are developed, the vegetation and organic topsoil are stripped away, the complex natural

topography is graded to uniform slopes, the soil is tightly compacted by heavy construction equipment, and impervious areas such as streets, sidewalks, parking lots, and buildings cover the landscape. As a result, much less water has a chance to infiltrate into the soil and therefore, the quantity of stormwater runoff drastically increases after the site is developed (Figure 1.2).

To manage the higher rates and larger volumes of runoff, drainage systems have historically been designed to remove the stormwater from developed areas as quickly as possible. This practice adequately served its purposes during the early days of Greensboro's development. However, the recent urbanization and corresponding increased runoff has produced drastic changes to stream channel geometry, stream hydrology, and floodplain expansion.

**Figure 1.2: Changes in Water Balance due to Urbanization**

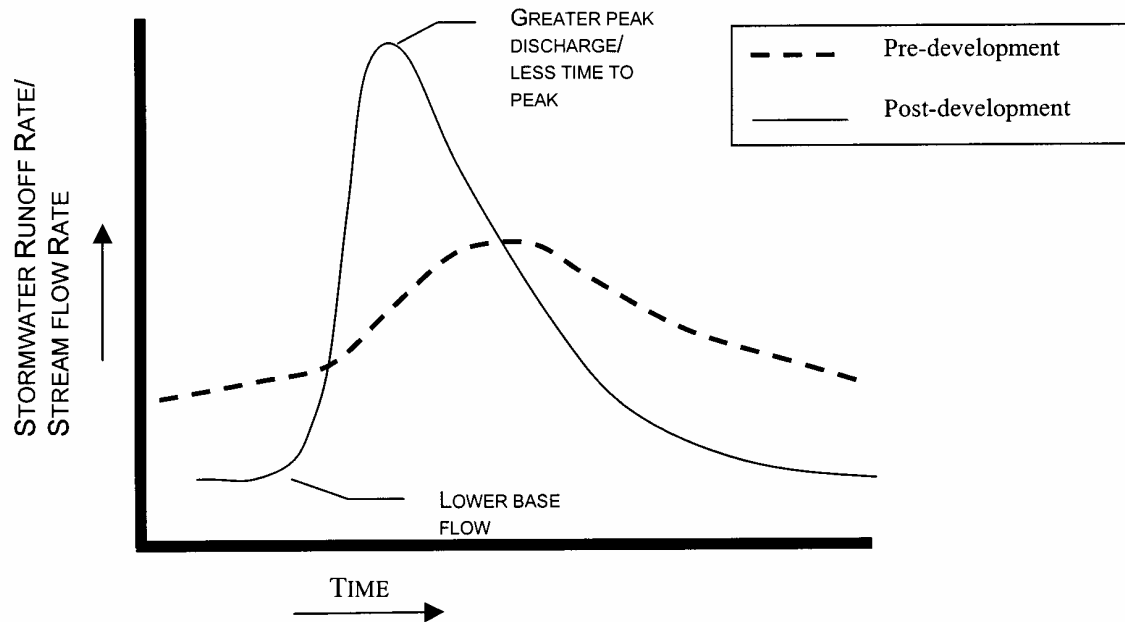


Source: CONTROLLING URBAN RUNOFF, METROPOLITAN WASHINGTON COUNCIL OF GOVERNMENTS

As higher flowrates are experienced in streams (Figure 1.3), streams naturally increase their cross sectional area to accommodate the increased flow. The stream will deepen and widen, often resulting in high vertical banks that are unstable. As the watershed continues to urbanize, the stream will continue to erode away its channel banks and bottom.

Stream erosion contributes to water quality problems by increasing the sediment loading in the stream flow which increases turbidity, degrades aquatic habitat, and fills in slow moving surface waters more rapidly. Also, eroded banks have created unsightly conditions and, in some cases, damage to adjacent public and private property, as well as a potential safety hazard.

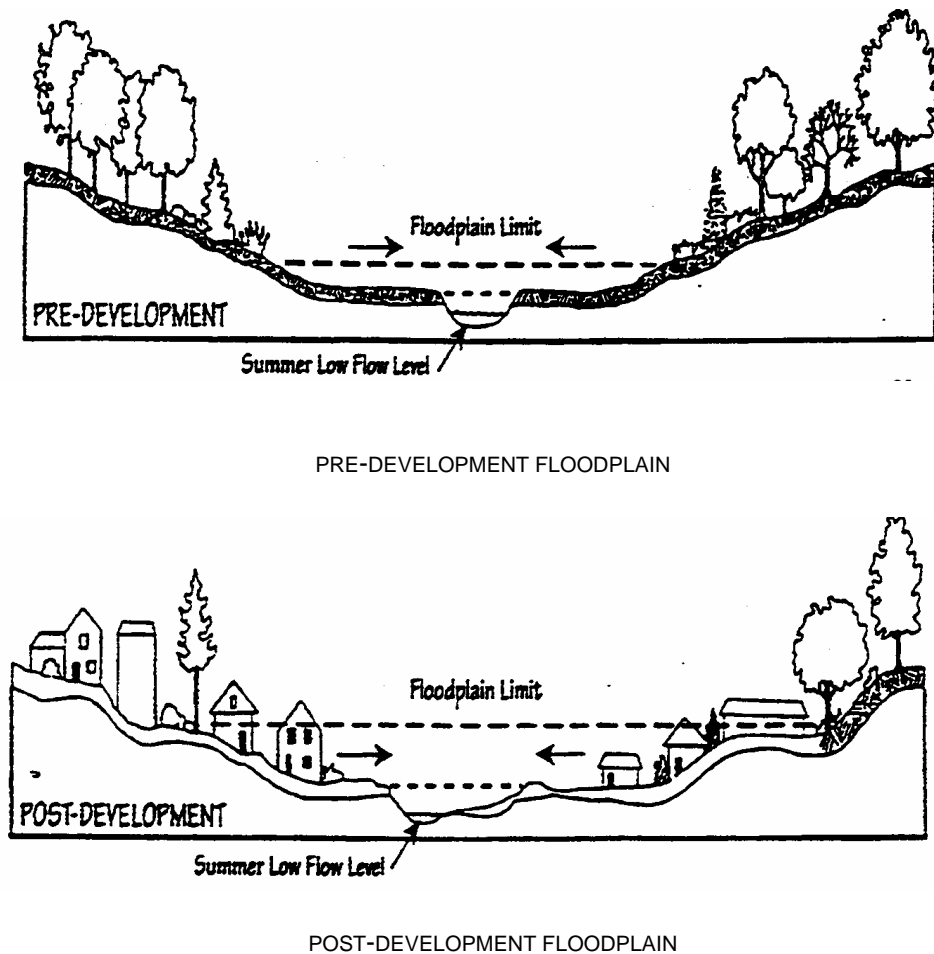
**Figure 1.3: Changes in Hydrology due to Urbanization**



As previously stated, in urban areas the majority of precipitation is converted to surface runoff that quickly discharges to the stream. Thus, the infiltration of precipitation into the soil is significantly reduced which results in lower groundwater (base) flow. The base flow supplies streams with steady flow during dry periods. This reduction in base flow may cause streams that used to be normally wet during the year to “dry up” and only convey runoff during and shortly after a rain storm event. The aquatic habitat in the stream section may not be able to survive. In larger urban streams the quantity and depth of stream flow during dry periods will generally be less, which may impact the diversity of fish habitat and their ability of passage.

In addition, the increased stream flow volumes and rates associated with stormwater from urbanized areas tends to produce more frequent floods and cause expansion of the floodplain. For example, areas that were previously flooded only once during five years may flood every year, or even several times each year. Also, areas that were previously not flooded now may be within the floodplain and those properties in the floodplain will experience higher flood levels, as shown in Figure 1.4.

Figure 1.4: Changes in Floodplain due to Urbanization



SOURCE: CONTROLLING URBAN RUNOFF METROPOLITAN WASHINGTON COUNCIL OF GOVERNEMENTS

### **Pollutant Loading**

In addition to the changes in watershed hydrology, urbanization has adversely impacted surface water quality through pollution transported by stormwater runoff. According to EPA's report to Congress, urban runoff is the number two source of pollution in lakes and estuaries and the number three source of pollution in rivers (Horsely, 1997). Examples of pollution associated with urban stormwater runoff are shown in Table 1.1.

The City has performed monitoring studies to determine the effects that urbanization has on pollutant loading in stormwater runoff. The studies included collecting runoff samples from different land use areas within the City of Greensboro and determining the concentration of various pollutants. Table 1.2 summarizes some of the monitoring data collected between April 1995 and October 1998.

<b>Table 1.1: Examples of Pollution in Urban Runoff</b>	
<b>POLLUTANTS</b>	<b>EXAMPLES</b>
Floatables	Litter such as paper cups and plastic bags
Bacteria	Leaking sanitary sewers; septic tanks; animal wastes
Oil and grease	Vehicle drippings; improper disposal
Nutrients	Fertilizers; sanitary sewer leaks
Pesticides	Outdoor applications
Metals	Vehicle parts wear (brakes, tires, engine parts), paint
Thermal impacts	Runoff from impervious surfaces; loss of stream canopy

<b>TABLE 1.2: POLLUTANT EVENT MEAN CONCENTRATIONS (MG/L) FOR DIFFERENT LAND USES IN GREENSBORO</b>			
<b>POLLUTANT</b>	<b>COMMERCIAL<sup>1</sup></b>	<b>RESIDENTIAL<sup>2</sup></b>	<b>OPEN<sup>3</sup></b>
Cadmium	0.0009	0.0003	0.0003
Copper	0.02	0.01	0.003
Lead	0.02	0.024	0.005
Zinc	0.22	0.01	0.02
Ammonia Nitrogen	0.65	0.51	0.50
Biochemical Oxygen Demand 5-Day (BOD)	33.92	20.79	6.25
Chemical Oxygen Demand (COD)	99.79	86.26	33.13
Nitrate	1.48	0.76	0.19
Dissolved Phosphorus	0.38	0.31	0.26
Total Phosphorus	0.66	0.35	0.29
Total Dissolved Solids (TDS)	120	98	90
Total Suspended Solids (TSS)	157	87	45
Total Kjeldahl Nitrogen (TKN)	2.1	1.46	0.53

<sup>1</sup> Heavy Commercial Land Use – 90% imperviousness

<sup>2</sup> Residential/Institutional Land Use – 50% imperviousness

<sup>3</sup> Open Park/Undisturbed Land Use – 2% imperviousness

From Table 1.2 it can be seen that pollutant concentrations generally increase as urbanization intensifies.

Urbanization has major impacts on the hydrology of watersheds in the City and the quality of our limited water resources. For this reason, it is crucial that stormwater BMPs be implemented to help offset the impacts of development through proper management of pollutant sources and stormwater runoff.

### *1.2.2 Stormwater Management Regulations and Policies*

To address the adverse effects of urbanization on water quality, Federal, State and local regulations have been adopted to protect the quality of surface waters. In the past, regulations targeted point source discharges such as effluent from wastewater treatment facilities, but now regulations also require pollution control of stormwater runoff.

#### NPDES Discharge Permits

With the Clean Water Act, the EPA mandated that it is illegal to discharge any pollutant to “waters of the United States” without a National Pollutant Discharge Elimination System (NPDES) Permit.

##### **Industrial Stormwater Permit**

Stormwater runoff from “Industrial Activities” is considered a discharge that is illegal without an NPDES Permit. Generally, the Industrial NPDES Permit requires certain industries to develop and implement a Stormwater Pollution Prevention Plan (SWPPP), which includes various BMPs to minimize pollution to surface waters.

##### **Municipal Stormwater Permit**

The City of Greensboro and other municipalities with a population over 100,000 (Phase I cities) are required to obtain a NPDES Municipal Separate Storm Sewer System (MS4) Discharge Permit. The Permit requires the development and implementation of a Storm Water Quality Management Program (SWQMP) to control the discharge of pollutants from the municipal separate storm sewer system to the maximum extent practicable. The City of Greensboro established the Storm Water Services Division to administer and manage this program. Storm Water Services is responsible for monitoring of water quality in streams, stormwater master planning, providing public environmental education, implementation of capital improvement projects, and other activities aimed at improving the quality of our surface waters and management of stormwater runoff.

To fund the Storm Water Services Division, a stormwater utility fee is assessed on all properties within city limits. Residential properties are assessed a flat rate,

while non-residential properties are assessed a fee based on the amount of impervious area that exists on the property.

### Water Supply Watershed Protection Requirements

The City of Greensboro utilizes and depends on a series of lakes on the Reedy Fork Creek in the northern region of the city for its drinking water supply. Due to rapid development in the watershed of the water-supply lakes, Guilford County and subsequently the City adopted a Water Supply Watershed Protection Ordinance in the mid 1980s to protect the Reedy Fork (Greensboro) watershed (refer to Appendix A for maps showing the Greensboro watershed). There are other protected drinking water supply watersheds besides the Reedy Fork watershed where a portion of the watershed is within the jurisdictional boundaries of the City. A portion of High Point, Randleman Lake, and Burlington watersheds are regulated by the City of Greensboro.

In the early 1990s, the State of North Carolina adopted regulations that set forth minimum watershed management requirements to protect drinking water supplies and required local governments to adopt and enforce these regulations within their water supply protection ordinance. In 1999, the State set forth new regulations for increased protection of the Upper and Lower Randleman watersheds. These regulations were adopted in the City's ordinance in December 1999 (see Appendix A). The State regulations serve to protect water supply reservoirs and their watersheds by imposing restrictions on "new development" in the following ways:

- ⇒ **limits on built-upon area**
- ⇒ **use of stormwater BMPs**
- ⇒ **protection of buffers along streams and lakes**

To enforce these regulations, the City requires that before any new development or re-development activities begin on a site located within a protected water supply watershed, a *Watershed Development Plan* must be submitted to the City for approval. The Watershed Development Plan, when required, should be incorporated into the *Stormwater Management Plan* as described in the following section.

The Watershed Development Plan must show that built-upon surfaces do not exceed the maximum percentage of built-upon area allowed. Built-upon area includes all impervious surfaces but also includes some areas that are partially impervious (e.g. gravel areas, dirt roads, etc.). The amount of built-upon area that is allowed on new development sites in a particular watershed depends on the classification of the watershed.

For "high density" development sites, the Watershed Development Plan must show how structural BMPs will be implemented to improve the quality of runoff from the site. The structural BMPs must be proven facilities and at a minimum meet the design criterion of



85% removal of total suspended solids (TSS) from runoff resulting from the first one inch of rainfall.

For “low density” development sites in the General Watershed Area, the Watershed Development Plan must indicate that the site design will minimize impacts to the environment. A passing score on the “General Watershed Area Performance Scoresheet” is required before a “low density” development can be approved for watershed protection. Low density development in the watershed critical area has different requirements.

The Watershed Development Plan must also show buffers along streams that are required to be protected. The type of streams that are required to be protected and the development activity that is allowed in the buffer may differ in each watershed.

This manual gives guidance on site design techniques to reduce impacts to the water-supply watersheds, and design criteria for structural BMPs to meet the requirements for high-density development. For items required on the Watershed Development Plan refer to Section 2. For more information on specific regulations in the water supply watersheds, refer to Section 2 of this manual and the City’s water supply watershed protection ordinance, which can be viewed online at [www.ci.greensboro.nc.us](http://www.ci.greensboro.nc.us).

### Storm Water Management Ordinance

Chapter 27 of the City Code of Ordinances is the Storm Water Management Ordinance. The main objective of this ordinance is to provide enforcement authority to meet the City’s municipal NPDES Permit and associated SWQMP.

Another key objective of this ordinance is to protect properties from potential stormwater quantity and quality problems. Potential problems include increased flooding and drainage problems due to inadequate or lack of conveyance systems and excessive stream bank erosion/channel widening due to increased runoff from developed areas.

On March 16, 1999 and April 4, 2000, the City Council adopted amendments to Chapter 27 of the Greensboro Code of Ordinances (Section 27-22) to control the adverse effects of increased stormwater runoff associated with newly developed or redeveloped sites. The revised ordinance requires all new development within the city limits to submit a *Stormwater Management (SWM) Plan*.

The SWM Plan must show stream buffers along all open (1) perennial streams and (2) drainage channels draining an area greater than 50 acres. The SWM Plan must also include an *offsite stormwater conveyance system analysis* that shows the effects the development will have on the downstream properties including a determination if the development will cause or increase quantity or quality problems. If the analysis shows that negative impacts will result, stormwater management improvements including structural and/or non-structural BMPs are to be implemented to minimize the impact.

Section 2 of this manual provides basic technical guidance including suggested analysis and design procedures to meet the requirements of the City of Greensboro's stormwater management ordinance. The information provided in this manual is not intended to be exhaustive, but rather to represent a concise collection of established, technically sound, and efficient means to produce stormwater management plans that may include non-structural and/or structural facilities to satisfy requirements of the City's stormwater quantity management ordinance. The ordinance provides flexibility for the City to work with developers and engineers to provide stormwater management facilities to minimize the adverse downstream impacts of stormwater runoff, but does not require the proliferation of facilities that may provide minimal benefit to the citizens of Greensboro and/or the public drainage system.

### Stormwater Utility Credit Policy

A stormwater utility fee is assessed on all properties within city limits. Since the main goals of the City are to reduce the amount of pollutants that are discharged to surface waters and to minimize stream and property damage associated with increased flowrates, the City offers credit on the stormwater utility fee to those who implement approved stormwater BMPs on-site.

This manual provides guidelines for BMPs to be considered to receive credit. Refer to the City's *Stormwater Utility Credit Policy* for more information regarding credit opportunities, including the actual credit that can be awarded for implementation of BMPs.